Paul E. Hosier

Recreational Off-road Vehicle Impacts In Coastal North Carolina

North Carolina's beaches, once trodden by sunbathers, swimmers, fishermen, surfers, and beachcombers, are now overrun with a mechanical mode of enjoying the beach environment: the recreational off-road vehicle (ORV). In 1970, four-wheel drive vehicles were an uncommon sight; they were viewed as a novelty and an extravagance. Today, however, the spring and fall months are marked by lines of mobile sports-fishermen along the sandy beaches near Oregon Inlet, Cape Hatteras Point, Drum Inlet, and Fort Fisher Beach. At the first sign of summer, surfers, sunbathers, and swimmers stuff their boards, blankets, and lunches into dune buggies and race to the beach. Even beachcombers can now cover more beach area with a recreational vehicle, collecting shells and other coastal treasures on remote, previously inaccessible beaches.

This dramatic change in the use of the beach environment in North Carolina has not occurred without leaving its mark. Long stretches of pristine beaches now have off-road vehicle tracks; unthinking ORV enthusiasts have created crossovers and roads throughout the dunes and grasslands; local governments are required to expand manpower and expend money to control vehicle use at the shore. The ORV phenomenon has appeared suddenly; few county or local governments were fully prepared to deal with the vehicles and their effects. Some communities immediately banned ORVs; others developed ordinances specifically addressing how, when, and where recreational vehicles may be used on the beach. A few communities have yet to develop regulations related to off-road vehicle operation.

This paper describes how and where recreational off-road vehicles are used most intensively along the barrier beaches of North Carolina, discusses the effects ORVs have on the beach environments and organisms, proposes management guidelines for off-road vehicle use based on scientific research, and discusses the variety of ordinances now in effect in North Carolina.

POPULAR ORV BEACHES

In Currituck County, Currituck spit is characterized by a number of large dunes or medaños, similar to Jockey's Ridge in Dare County. The dunes have been exploited by off-road vehicle users. Hill climbing has been a favorite recreation in these deserted and nearly inaccessible areas. Vehicular impact on the unvegetated, migrating sand dunes has been largely superficial; however, acres of vegetated sand flats surrounding the medaños have been denuded by vehicles (Fig. 1). This activity has been nearly stopped with increased law enforcement, however violations continue to be noted on this unpopulated beach.

The twelve-mile beach in the Town of Nags Head is an area where extensive off-road vehicle use occurs. Local interests sponsor fishing tournaments to spark ORV use and the proximity of the town to Cape Hatteras National Seashore also makes this area attractive to, and well-used by, ORV enthusiasts. The conflict between concerned beachfront property owners and organ-

Paul E. Hosier is associate professor of Biology at the University of North Carolina at Wilmington. He received his Master's degree in botany from the University of Massachusetts and a PhD. in plant ecology from Duke University. Hosier has been studying North Carolina Barrier Islands since 1970.

Figure 1. The congregation of vehicles for hill climbs has denuded extensive area of vegetated flats surrounding the dune.
Photo by Paul Hosier

ized sports-fishing groups has created a potentially difficult situation within the town. Excellent ORV regulation enforcement has managed to minimize adverse recreational impacts.

Within Cape Hatteras National Seashore, the inlets and the cape act as magnets for mobile sports-fishermen. At Oregon and Ocracoke Inlets, vehicle traffic has compacted sediments along the unvegetated portions of the beach. Near Ocracoke Inlet, sand flat vegetation has been altered by ORV tracks. Chronic operation of ORVs has kept natural stabilizing vegetation from invading the flats. In the vicinity of Hatteras Inlet, southwest of Cape Point, an extensive network of sand roads has been created by ORV activity. Dunes and grasslands have been denuded and blowouts are evident. New roads are constantly established as old roads become impassable.

"NUMEROUS, EXTENSIVE DEEP SAND ROADS HAVE BEEN CREATED ALONG THE WIDE BERM ON THESE ISLANDS."

Portsmouth Island and Core Banks, now part of Cape Lookout National Seashore, have had a long and glorious history of off-road vehicle use. Sports-fishermen ferry old vehicles to the fishing camp concessions on the banks. From here, the vehicles provide the mobility necessary to take advantage of the 45 miles of beach open to fishermen. Numerous, extensive, and deep sand roads have been created along the wide berm on these islands. If the old vehicles failed to operate or became hopelessly bogged down in sand, they were often abandoned on the islands. Recently, the National Park Service contracted for the removal of nearly 2,500 vehicles from Core and Portsmouth Islands.

Emerald Isle, located at the western end of Bogue Banks in Carteret County, is an important off-road vehicle use area. For years, vehicles have traversed the beach, primarily for recreational fishing. During this period, no beach access areas were officially designated. ORV damage is evident where vehicles crossed dunes to reach the beach. One official access ramp now exists; the community is in the process of designating and improving other access areas.

West Onslow Beach has had a similar history of vehicle use. Vehicles use the unincorporated portion of West Onslow Beach. Illegal access was used until Onslow County recently designed access ramp sites. Lack of enforcement of vehicle regulations has resulted in some dune destruction at the beach.

Fort Fisher Beach, a portion of the Fort Fisher State Historic Site, is a major recreational off-road vehicle use area within North Carolina. The beach is publicly owned, however, little enforcement of ORV regulations has been attempted by state or local governmental units. Extensive dune and marsh destruction has occurred. The dune system is criss-crossed by sandy trails, and vehicles encroach upon the marsh along a three-mile section of the historic site (Fig. 2). During the summer, as many as 200 vehicles of all descriptions can be found along and throughout the beach, dunes, marsh, and sand flats. Hundreds of people use the area for recreational pursuits, including fishing, swimming, sunbathing, and shellfishing. We recently observed an individual water skiing along a sound-side creek--he was being pulled by a four-wheel drive vehicle.

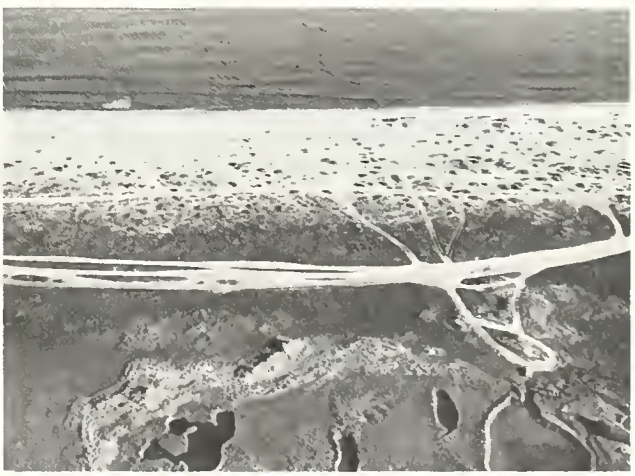

Figure 2. Lack of law enforcement allows vehicles to travel throughout the dune and marsh ecosystems.
Photo by Paul Hosier

OFF-ROAD VEHICLE IMPACTS IN THE COASTAL ENVIRONMENT

The barrier beaches which dominate the coastal area include a number of different environments which are affected by ORV use (Fig. 3). The natural processes and organismic composition of these units differ. The response to ORV impacts is variable, thus each major unit will be discussed separately.

The berm is the most dynamic system on the barrier beach. It includes the intertidal zone between low tide and the toe of the most seaward dune. This highly malleable environment can withstand the physical impacts of vehicles to the greatest extent of any system on the barrier beach. It is not, however, without impact. Both the fauna and flora of the area are vulnerable to vehicle impacts. Our studies at Cape Hatteras National Seashore and a study at Assateague Island, Virgina (Steiner and Leatherman, 1980), have found that ghost crabs (*Ocypode quadrate*) are vulnerable to vehicle operation. Where ORVs are present, crab populations are lower than in adjacent control or non-used areas. The amount of population change is related to the intensity of use. Areas near beach access ramps show the greatest decline in ghost crab populations. Direct vehicle kills of crabs do occur, especially at night; however, destruction of burrows and traffic stress are likely the main contributors to population reduction. Crab populations may be reduced as much as ninety-five percent in the vicinity of access ramps.

Environmentally concerned persons often cite ORV impacts on logger-head turtles (*Carettta caretta caretta*), an endangered species. Data are now being accumulated to support this contention. Use of headlights at night may reduce nesting success, since headlights deter female turtles from coming ashore to lay eggs. We have conducted a study to determine the effect of non-smooth beaches on hatchling movement to the ocean. The results indicate that turtle hatchlings are impeded from reaching the surf by microtopographic variations created by the action of pedestrian traffic or vehicle tracks. The longer time required for turtles to reach the surf makes them less likely to survive the trip; gulls and raccoons will find them easy prey.

At Cape Lookout National Seashore, our study has revealed that deep ORV tracks trap seeds of sea oats (*Uniola paniculata*) as they are blown across the beach. The captured seeds are subsequently buried by drifting sands. Germination of the seeds occurs following burial and lines of sea oat seedlings are visible along the upper beach. Later in the year, vehicles use the same beach for travel. Vehicle tires churn up the sand and expose the roots of the plants, thus destroying the seedlings they originally aided in planting.

The effect of ORVs on colonial nesting bird activity has not been documented in North Carolina. At Cape Cod National Seashore, vehicles passing through the colonies have been shown to kill birds and crush eggs. Along the North Carolina coast, we have observed dead birds in the tracks of ORVs. The nestlings usually seek protection from passing vehicles in the tracks of vehicles. The passage of subsequent vehicles through the same tracks results in the death of many birds. The pro-

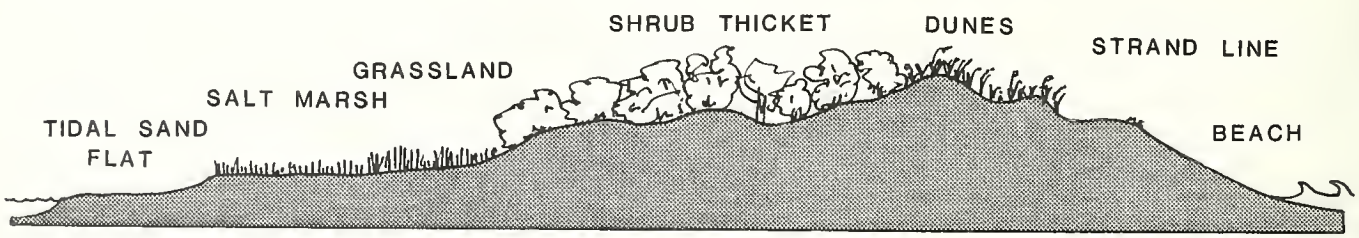

Figure 3. Generalized barrier island ecosystem diagram indicating environments most severely affected by off-road vehicle use.

Graphic by Paul Hosier

tective coloration of the birds prevents ORV operators from locating nestlings. The parent birds are often flushed by the passage of a vehicle or by pedestrians walking into the nesting area. The unprotected eggs quickly overheat without the parent birds and unhatched birds die.

Within dune and grassland areas, ORV impacts are severe. For example, at Fort Fisher, North Carolina, the dune system is traversed by vehicles, motorcycles and dune buggies. There, recreational vehicles without proper controls on their movements have destroyed significant areas of dunes. The non-cohesive nature of dune sands results in severe impacts by undermining and exposing plant roots and rhizomes, and by exposing sand to the forces of the wind. The most disturbing feature of ORV effects in the dune system is the extremely low level of impact necessary to disturb the vegetation and the sands. Our studies show that vegetation is completely destroyed on a dune with only 100 passes. One to five passes heal slowly and are visible for at least a year. Following disruption of the vegetation, wind action mobilizes the sand and enlarges the initial impact area.

Controlled impacts on dune systems indicate that 100 vehicle passes can reduce the vertical dune profile by as much as one foot. The amount and extent of damage will vary depending upon vehicle weight and speed, tire size, pressure and tread design, and slope of the dune.

Results of research at Cape Hatteras National Seashore indicate that only ten passes of a vehicle are sufficient to reduce plant cover in grasslands by sixty percent; while fifty passes reduces vegetation cover by ninety-five percent. Chronic impacts spaced weeks apart continually maintain low vegetation cover in these grassland areas. Recovery of affected areas is initiated by the invasion of annual plant species. These plants are gradually replaced by perennial grasses and forbs which re-establish a dense cover and extensive root network. With severe denuding, recovery is very slow. The vegetation within the dunes and grasslands at Fort Fisher Beach has been so severely altered by ORV activity that it will require intensive planting of grasses and the placement of sand fencing to assure dune development.

We initiated a study of ORV effect on the patterns of vegetation at Fort Fisher Beach (Hosier and Eaton, 1980). A number of vegetative and physiographic parameters were measured. Significant differences between ORV-impacted (Fort Fisher) and control (Bald Head) beaches were found (Table 1). The number and diversity of species were lower on the ORV-impacted beach, and the areal extent of grasslands was decreased. Total vegetation cover on the dunes showed nearly a fifty percent decrease at Fort Fisher Beach when compared with the control. These changes are detrimental to the stability of the island. Oceanic overwash during storms will likely be more severe following devastation of dunes and grasses if vehicles are allowed to continue to use the area without restrictions.

In the same study, significant compaction of sandy substrates was detected. This alteration of the substrate tends to increase the water content of dry, sandy soils and may cause the formation of poorly drained sites, especially in the marsh. Salt pan formation may occur.

TABLE 1

Parameter	Dunes			Grassland		
	Bald Head	Fort Fisher	% Change	Bald Head	Fort Fisher	% Change
Species	15.00	13.00	-13.30	31.00*	12.00	-61.30
Aerial extent (%)	51.28	82.87	61.60	48.72	17.17	-64.80
Vegetation cover (%)	19.39	10.58	-45.40	53.29	38.53	-27.70
Unvegetated quadrats (%)	4.30	22.73	428.60	0.00	0.00	0.00
Species diversity	0.9482	0.8386	-11.60	1.0320	0.7436	-27.90

*Includes two species observed, but not found in quadrats.

Summary statistics and percentage change for dune and grassland vegetation on non-impacted Bald Head Beach and ORV-impacted Fort Fisher Beach.

Studies of the effects of off-road vehicles in the American desert have indicated a decrease in population of all animal species studied (Busack and Bury, 1974 and Bury et al., 1977). At Fort Fisher, we conducted a study to assess the effects of vehicles on small mammal populations, primarily rats and mice. Their density was determined on the affected barrier beach and the unaffected barrier beach. Despite the intrusion of vehicles and the destruction of dune, grassland, habitat, and food supplies, mammal populations were higher on the affected barrier beach (Table 2). Based on a survey of predatory animals, we found no foxes or snakes on Fort Fisher Beach indicating the lack of normal predators on the ORV-impacted beach. The highly adaptable mice and rats are probably able to withstand the intrusion of the vehicles into their habitat with greater success than the animals which prey upon them. As a result, their populations are unchecked by predatory activity.

TABLE 2

Animal Species	Number of small mammals/ 100 trap nights	
	Fort Fisher (ORV impact)	Bald Head (No-ORV impact)
House mouse *(Mus musculus)*	1.86	0.68
Rice rat *(Oryzomys palustris)*	1.72	0.87
Cotton rat *(Sigmodon hispidus)*	0.07	0.00
Total captures/ 100 trap nights	3.65	1.55

Comparison of small mammal captures on ORV-impacted and control beaches during four sampling periods from December 1979 to October 1980.

RECOMMENDATIONS

Based upon the results of off-road vehicle research, we propose several measures to mitigate or eliminate the negative impacts of ORVs on barrier beach environments of North Carolina.

1. *ORV use should be restricted to the intertidal wet sand environment.* Vehicles should be prohibited from using the area near the toe of the foredune and the strand line portion of the beach. Beaches and inlet zones which are prograding should be closed to ORV use. Vehicles crossing these areas destroy developing dune vegetation. This activity either produces or maintains an unstable beach. Sections of the beach which are narrowed by erosion and/or exhibit a steep profile should be closed to traffic, since at high tide, vehicles must intrude into the dunes to gain passage.

2. *ORV use on intertidal beaches should be suspended from 1 May to 15 October.* Closing the beach to vehicles during the summer season will diminish animal mortality and reduce conflicts between ORVs and pedestrians. Ghost crabs are most active from late spring until early fall. Similarly, loggerhead turtle nesting occurs from early May until early August and loggerhead turtle hatching continues into early fall. Both organisms will benefit from closure. ORV intrusions upon pedestrians will be virtually eliminated by suspending ORV activity during the summer months.

3. *Colonial bird nesting areas on the open beach should be clearly marked.* Vehicles should be prohibited from entering or crossing nesting areas. Vehicle trails should be routed around nesting sites as they are identified. Inspection of nesting areas by people on foot should be discouraged. Interpretive programs explaining the importance of maintaining nesting bird colonies should be implemented.

4. *ORVs should be strictly prohibited in coastal dunes.* Vegetation destruction, animal habitat alteration, and substrate changes caused by ORV operation in the dune system should be eliminated. Older dunes located away from the beach are exceedingly vulnerable. Without accreting sand, dune plants do not grow rapidly. Re-establishment of vegetation in these areas is a very slow process.

5. *ORV crossovers should be constructed with a protective surface, spaced widely along the beach, and carefully sited to reduce the potential for blowouts.* Wooden or aluminum mats are excellent materials for crossover construction. The natural contours of the dune system should be maintained during the construction process. Dune swales or saddles should be avoided in locating crossovers. Since the beach and dunes in the vicinity of crossovers are severely impacted by vehicles, a minimum number of crossovers should be constructed along a section of beach. This will concentrate the most severe impacts in a few sites (Fig. 4).

6. *Vehicle trails through vegetated areas of dunes and grasslands should be constantly maintained and graded.* Fort Fisher and Hatteras Inlet offer excellent examples of the problems created by minimal trail maintenance. Sandy roads quickly become rutted and then flooded without constant maintenance. When a section of a trail becomes impassable, new trails are blazed. The resulting network of trails increases the extent of damage to vegetation and wildlife.

7. *Fencing, planting, and posting can be used effectively in restricting or eliminating vehicle use in specific areas.* Our research has involved closure of specific trails and areas to assess vehicular impacts. With posting of explanatory signs and fencing or posts, vehicle users are likely to respect the closed areas. Revegetation of denuded trails will make users less inclined to violate the area; this will speed recovery.

8. *ORVs should be prohibited from crossing salt marsh and tidal sand flats.* Based upon studies conducted by Brodhead and Godfrey (1979), a few passes by a vehicle are sufficient to create persistent deep ruts in a peaty salt marsh. These ruts can alter drainage patterns within the marsh and create salt pans. Our studies indicate a similar result when sediments are compacted by vehicle traffic. Organisms in the tidal sand flats were crushed or otherwise reduced by off-road vehicle activity in New England studies. Corresponding effects can be anticipated for North Carolina tidal flats. Godfrey et al. (1977) have discussed guidelines for ORV use based on studies at Cape Cod National Seashore. A number of management concepts discussed in the paper apply to North Carolina barrier beaches.

Figure 4. Using wooden or aluminum crossover mats can reduce the impact of vehicles on the dunes.
Photo by Paul Hosier

OFF-ROAD VEHICLE ORDINANCES

Many coastal communities have passed local ordinances which address the use of ORVs within their jurisdiction. They range from well researched, well documented, and thorough ordinances to superficial, expedient, unenforceable ordinances. Local legislation is highly variable, often reflecting a community's perception of appropriate use of ORVs based upon the level of input from ORV users and individuals and groups opposed to vehicle use. For example, some ordinances specify a closed season. Closing dates for ORV use vary from Easter Sunday at Ocean Isle to 1 June at Indian Beach.

"THE UNEVENNESS AND VARIABILITY OF ORV REGULATION AND ENFORCEMENT IS DISTURBING."

Opening days similarly vary. In Carteret County, the beach opens for ORV use on 1 September; in Nags Head, opening day is 1 October. The National Park Service (Cape Hatteras and Cape Lookout) does not recognize a season. Instead, at Cape Hatteras, specific sections of the beach are closed to traffic to avoid conflicts with swimmers and bathers.

Ordinances differ in the types of off-road vehicles allowed on the beach (Hosier and Eaton, 1979). The Town of Nags Head allows only four-wheel drive vehicles, while the adjacent Cape Hatteras National Seashore permits all four-wheeled vehicles. Onslow County allows all four-wheeled and three-wheeled vehicles, but bans motorcycles. Atlantic Beach allows all two-, three-, and four-wheeled vehicles without discrimination.

Speed laws vary from fifteen miles per hour at Holden Beach to twenty-five miles per hour in Currituck County and Nags Head. Many ordinances do not specify a speed limit. Permits and fees are established locally and are not consistent state-wide. Nags Head requires a permit with a fee of twenty-five dollars; Surf City and Holden Beach require a fee of ten dollars. Cape Lookout and Cape Hatteras National Seashore require a permit, but no fee.

Both Currituck and New Hanover Counties expressly forbid hill-climbing and beach-racing; in Dare County, commerical fishermen are given special exemption from ORV regulations; the Town of Nags Head forbids night-driving and specifies that North Carolina motor vehicle laws be enforced, including driving under the influence and reckless driving.

Enforcement of existing ORV laws exhibits considerable variation. Nags Head town police patrol the beach several times a day, citing violators when necessary. At Fort Fisher State Historic Site, confusion over law enforcement

responsibility and jurisdiction has led to the complete lack of patrol or law enforcement. The unevenness and variability of ORV regulation and enforcement is disturbing. Local governmental and state-wide management and enforcement agencies have been slow to respond to the rapid development of the ORV problem in the coastal area. The speed with which the ORV phenomenon occurred caught state and local government personnel without sufficient resources or information concerning the impact of vehicles, and few resources for controlling impacts.

"THE BARRIER BEACHES WHICH DOMINATE THE COASTAL AREA INCLUDE A NUMBER OF DIFFERENT ENVIRONMENTS WHICH ARE AFFECTED BY ORV USE."

THE FUTURE OF ORV USE

What does the future hold for recreational off-road vehicle use in North Carolina? First, unless a severe oil crisis reduces gasoline supplies, vehicle use will probably continue to increase. Sports-fishing is becoming increasingly popular as a recreational outlet. Second, ORVs are here to stay. Given the political, economic, and social climate of the coastal area, those who benefit from ORV use will not submit to a total ban on ORV beach traffic.

Explicit regulations will be required to manage ORV use on the beach. Scientific studies should be continued, primarily to determine how ORV impacts can be mitigated. Scientific input can be used to continually update off-road vehicle regulations and reduce negative impacts.

On a larger scale, ORV use should be assessed and monitored at the regional and state levels to determine the impact of vehicles. Thorough planning is necessary to insure that the ORV user can enjoy the beach without infringing on the rights of property owners and other beach users. This will be no easy task. It will require compromise from both sides of the ORV issue.

Photo by Paul Hosier

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